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A Reference Electrode Data Acquisition System For Cathodic Protection Studies

by

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ABSTRACT

Aluminum vinyl anti-corrosive paints and impressed current cathodic protection, both of which were subjects of extensive development in Canadian defence research laboratories, have substantially increased the length of time between dockings for hull maintenance on HMC Ships. Unfortunately, at least in Canada, the transfer of cathodic protection expertise to the private sector does not appear to have been completely successful. For example, the original cathodic protection system on the DDH 280-class ships did not provide enough protection in the stern, with resultant corrosion of rudders and A-brackets. When a new anode and reference electrode were finally placed in the stern, the initial current demand was so high that circuit breakers were blown, clearly indicating the need for additional protection in that area. Given the general lack of knowledge concerning the cathodic protection current distribution around the hull of a ship at sea and specific concerns about the systems in use on HMC Ships, the Esquimalt Defence Research Detachment initiated a research project to design and build a self-contained reference electrode data acquisition system. These electrode systems could be mounted at locations of interest around the ship hull without the need for through-hull penetrations or over-the-side cables.

The electrode unit can measure and record the potential of the hull/sea water interface at its location, along with a time/date stamp, every hour for up to one year, or every fifteen seconds until its memory is full. A prototype unit will be displayed and the results of trials on a simulated ship hull will be presented. Each electrode system would be connected to the hull by way of a mounting stud that was friction welded to the hull by divers. Issues involving the welding procedure, such as fire hazards and possible damage to internal coatings, will also be discussed. The data retrieval unit, which can be used by divers to program or download data from up to thirty electrode units, will be displayed and its underwater communications capabilities will be demonstrated. The information gained from these electrodes would identify any weaknesses in existing cathodic protection systems and provide vital data for the development of computer models to improve future designs.

A REFERENCE ELECTRODE DATA ACQUISITION SYSTEM FOR CATHODIC PROTECTION STUDIES

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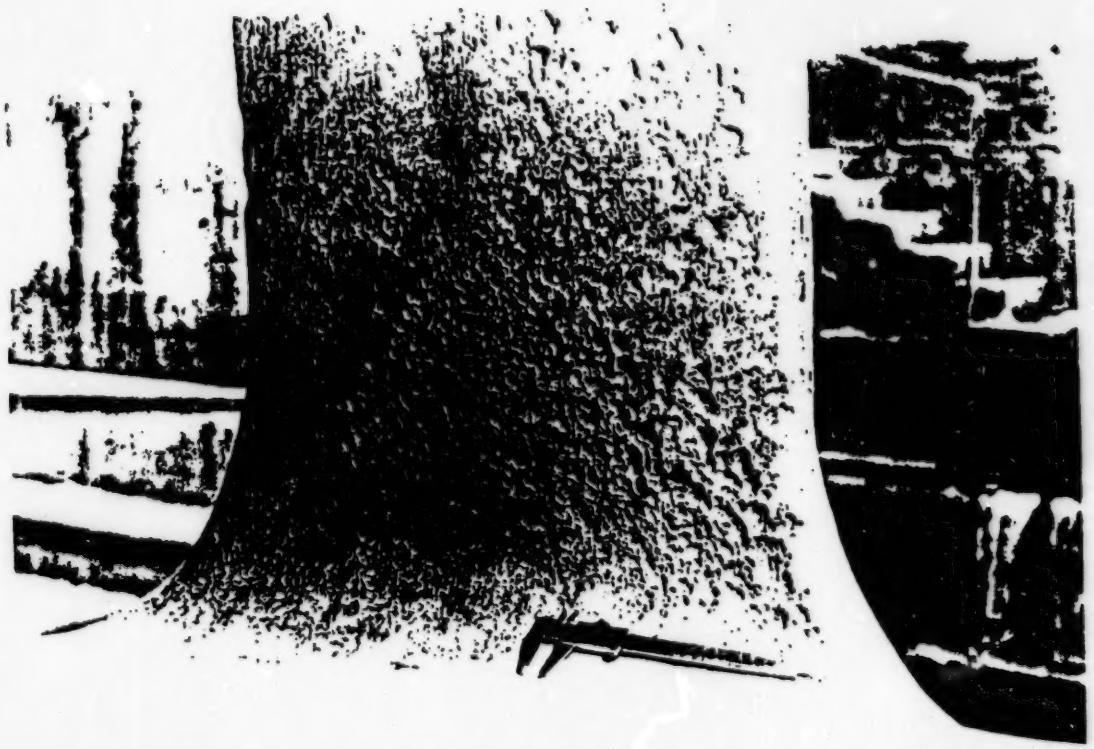
OUTLINE

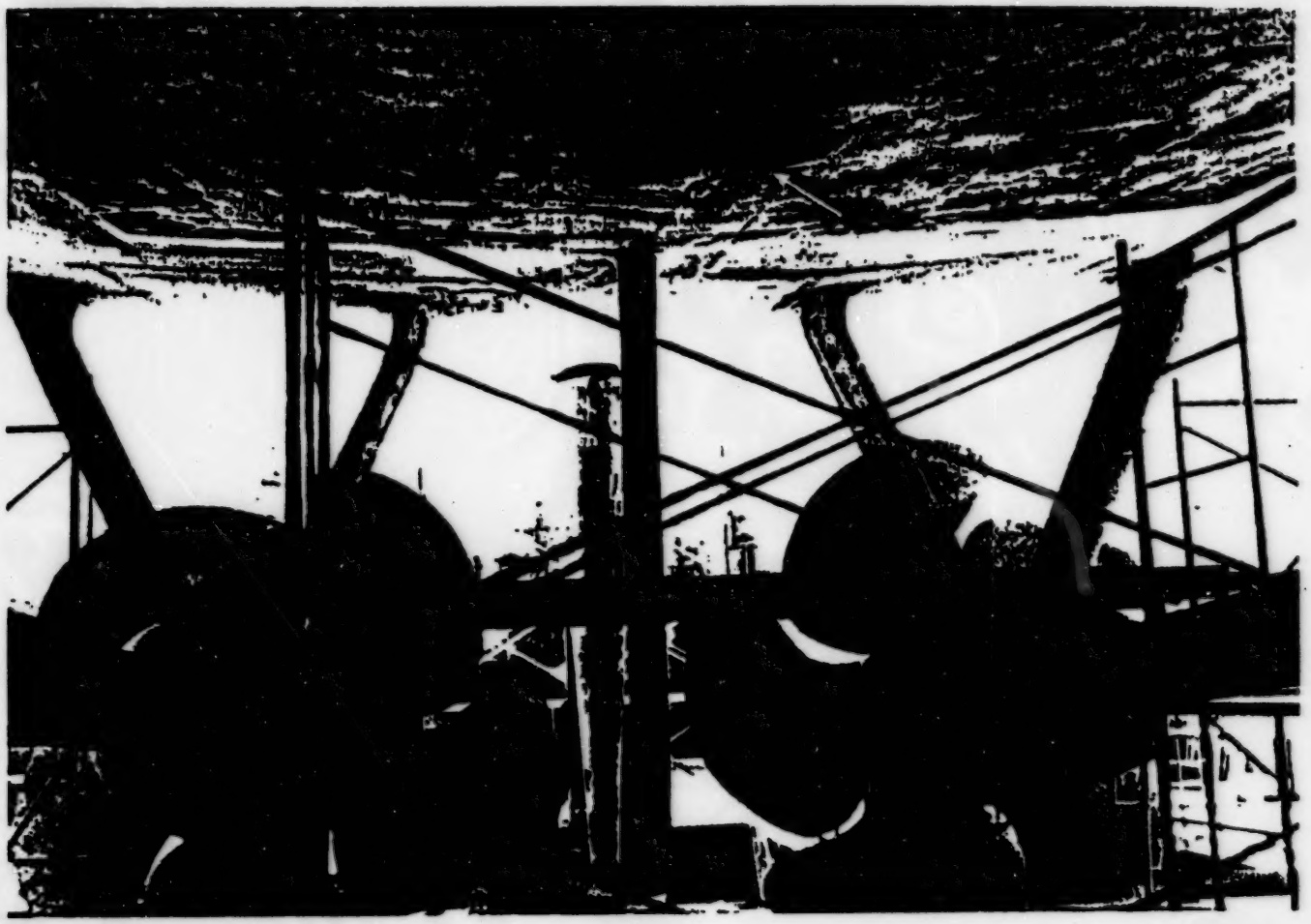
- NEED
- DESCRIPTION OF EQUIPMENT AND SOFTWARE
- TRIAL OF PROTOTYPE ON SIMULATED SHIP HULL
- DEMONSTRATION OF DATA RETRIEVAL
- POTENTIAL EXPERIMENTS

1. Aluminum vinyl anti-corrosive paints
2. Cathodic protection

- Substantially increased the length of time between dockings for hull maintenance.
- Transfer of expertise to the private sector not completely successful
- Original CP system on DDH 280-class did not provide enough protection in the stern: corrosion of rudders and A-brackets



Before CathodicProtection:
Cavitation damage on A-bracket of HMCS Cayuga (1956)



Stern Anode on Canadian Patrol Frigate

Aft Reference Electrode on CPF

Forward reference electrode for aft anodes

- **Question: Is the stern area of the CPF adequately protected if the "forward" reference electrode is used to control the current output from the aft anodes?**

- **Computer Modelling of Cathodic Protection**
  - **cost-effective design tool once model is developed**
  - **requires knowledge of the relationship between current output and "hull potential"**
  - **this relationship is dependent on the velocity of the ship**
  - **very little data for a ship at sea**

- "HULL POTENTIAL" really means:
- The potential of the steel/sea water interface with respect to a silver/silver chloride reference electrode.
- The potential of this interface varies with the amount of current passing through it. The variation is not linear.
- Experience has shown that a "hull potential" of -850 millivolts will prevent corrosion of the steel without damaging the paint.
- Need to place the reference electrode (which controls the amount of current from the anode) and the anode in locations which protect as much of the hull as possible.

- **AIM:**

- **Place a number of stand-alone reference electrodes at locations of interest around the ship hull to measure the "hull potentials" at those locations.**

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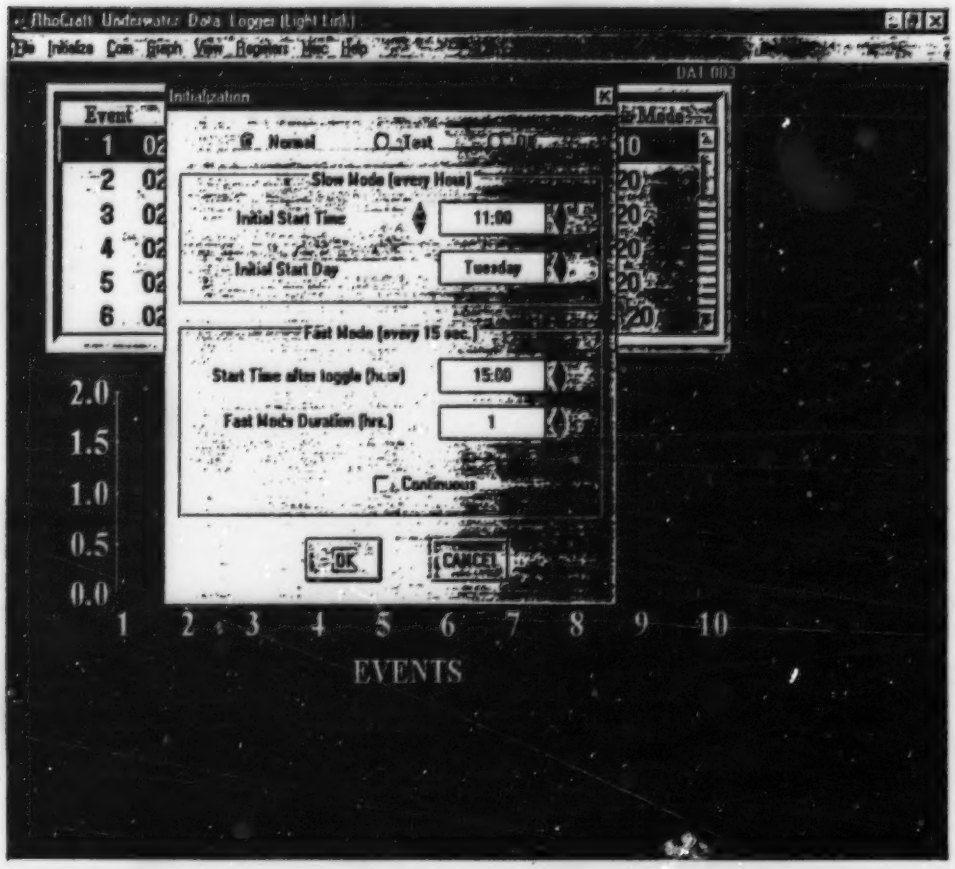
- **REQUIREMENTS:**
  - no through-hull penetrations or over-the-side cables
  - low profile to minimize turbulence
  - ability to acquire data for up to one year
  - data retrieval and system programming by divers
  - operation should be invisible to ship staff
  - ship hull easily returned to original condition after experiments completed

Self-contained Reference Electrode Data Acquisition System (Rhocraft R&D Ltd.)

1) Reference electrode module
   - records time/date, hull potential and water flow rate every hour for up to one year or every 15 seconds until memory is full or unit switched back to hourly measurements.
   - mounted on the hull using a stud attached to the hull by a diver with a friction welder
   - quickly removed in an emergency with stud ground off without damaging hull integrity

2) Data retrieval/Programming module
   - diver points the face of the retrieval unit at the electrode module and the two units establish communications
   - complete data transfer in 1 to 2 seconds at a distance of up to 1 m from the electrode.
   - data from up to 30 electrodes can be downloaded in a single session
   - reprogramming the electrodes in a similar fashion



Programming the Underwater Data Logger (UDL)
(This is the self-contained reference electrode unit)

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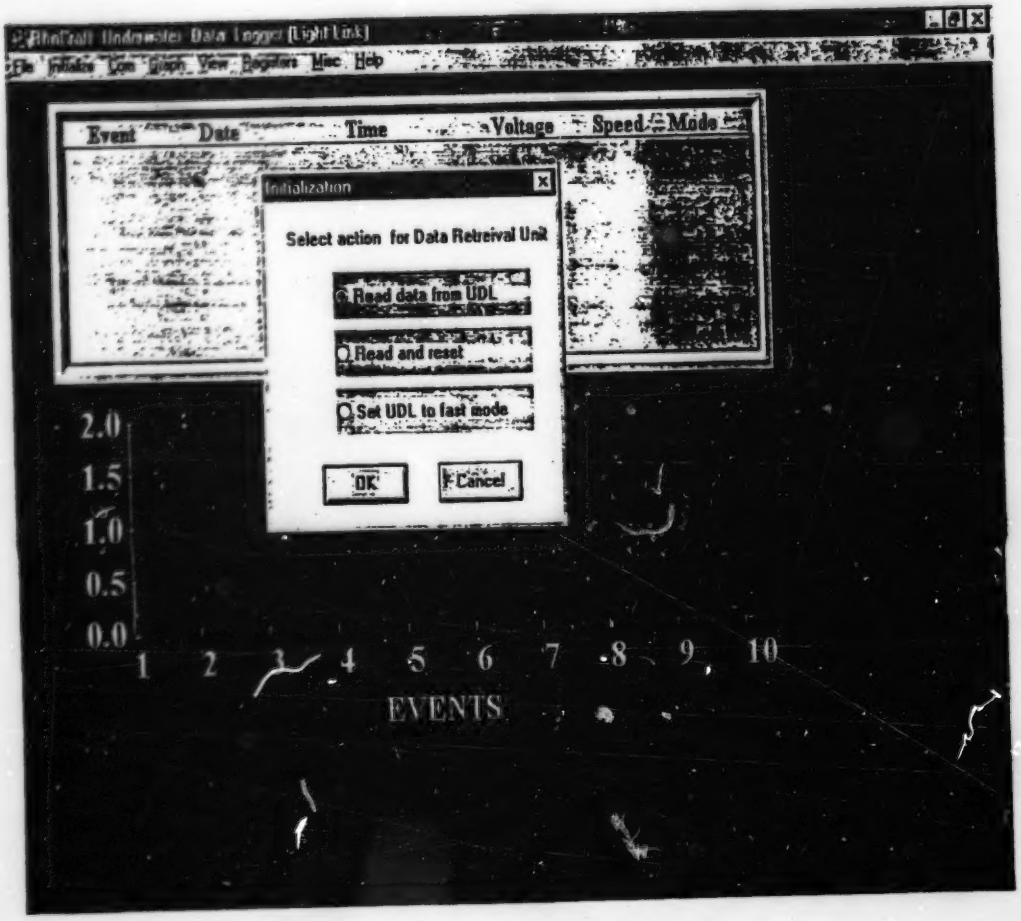
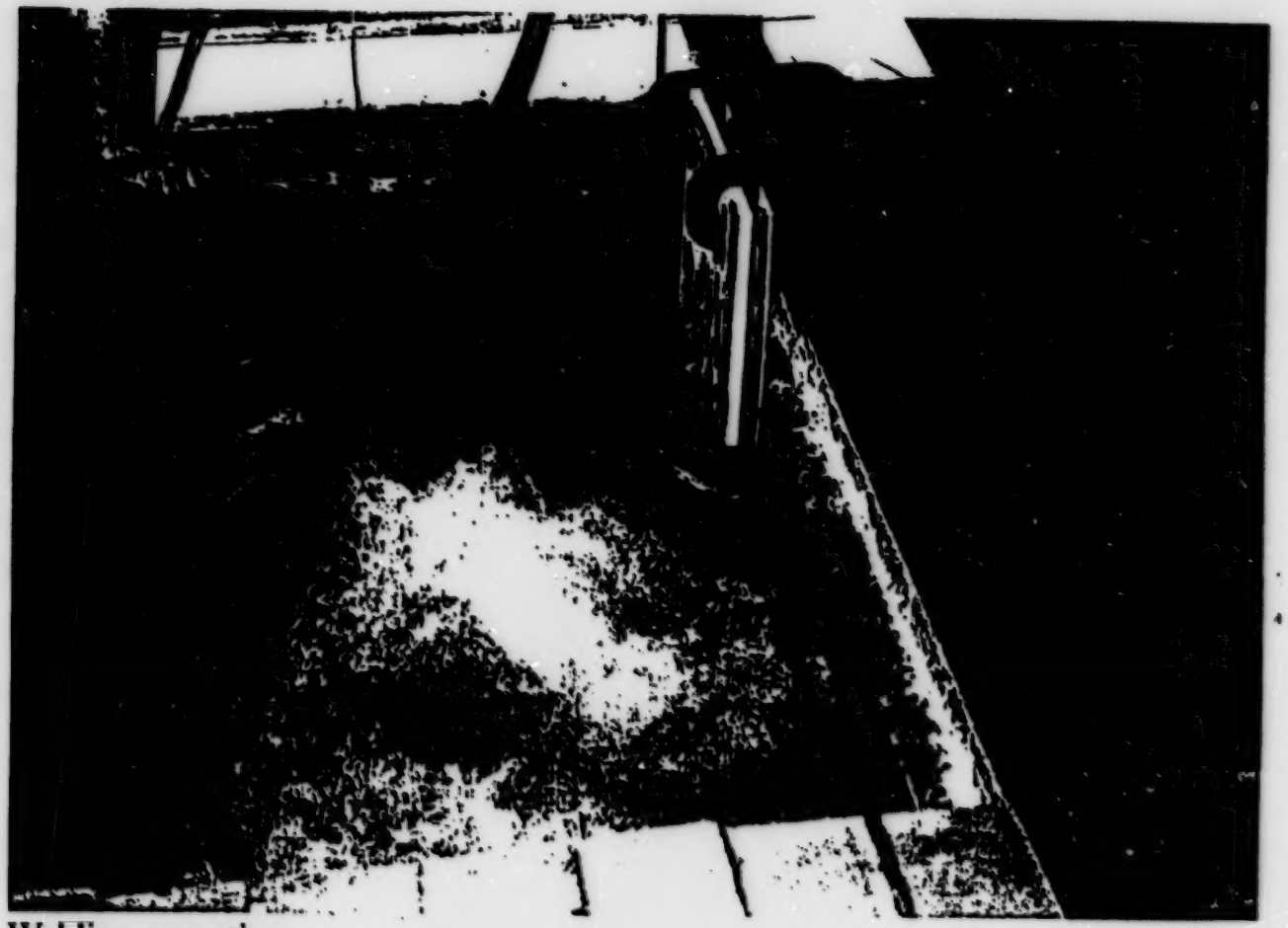


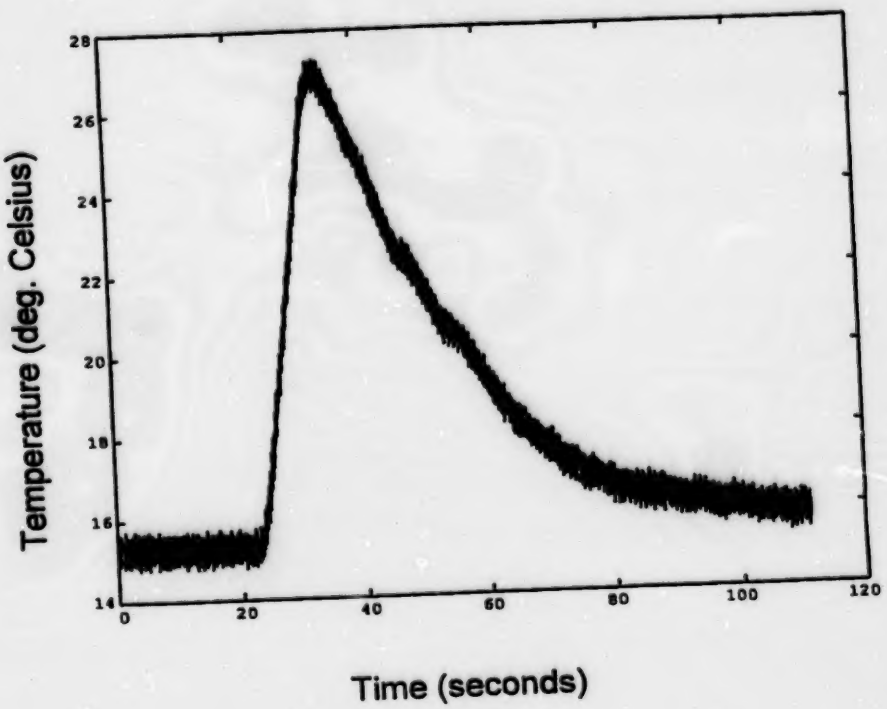
Programming the Data Retrieval Unit

Simulated Ship hull partially immersed in sea water (arrow at water line)

Friction Welding equipment

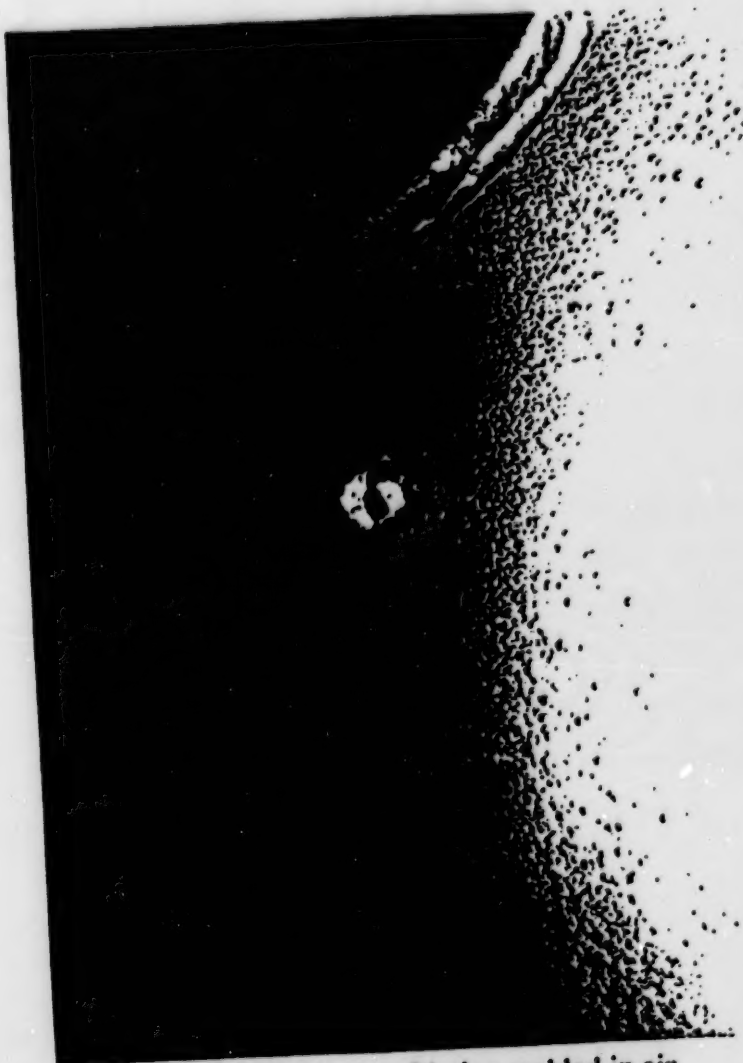


Welding operation



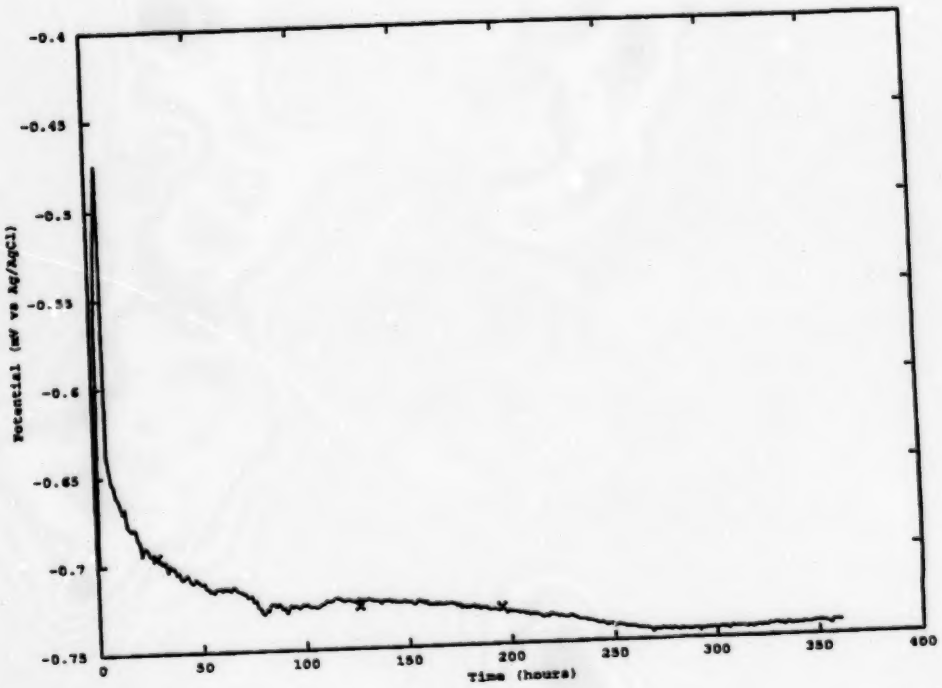
Temperature change on back (dry) side of hull plate 2.5 cm away from the centre of the friction weld.

Back side of weld: no paint damage



Back side of stud that was friction welded in air

Reference Electrode System mounted on simulated ship hull



Solid line represents the output from the reference electrode data acquisition system mounted on the simulated ship hull. Note that the true output involves a time and date stamp. The time scale has been converted for graphical presentation. The "x" marks indicate the potential as measured with a conventional reference electrode and digital multimeter.

USES

- EFFECTIVENESS OF CATHODIC PROTECTION SYSTEM
- RATE OF POLARIZATION / DEPOLARIZATION AT DIFFERENT LOCATIONS AROUND HULL
- EFFECTS OF TEMPERATE VERSUS TROPICAL WATERS
- EFFECTS OF VELOCITY - PROVIDE DATA FOR COMPUTER MODELS